STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
AIR POLLUTION CONTROL PROGRAM
205 JEFFERSON STREET, P.O. BOX 176
JEFFERSON CITY, MISSOURI 65102

EMISSIONS INVENTORY QUESTIONNAIRE (EIQ)

FORM 2.5 ORGANIC LIQUID STORAGE - FIXED ROOF TANK

SHADED AREAS FOR OFFICE USE ONLY

FACILITY NAME	FIPS COUNTY NO.	PLANT NO.	YEAR OF DATA

PLEASE PROVIDE ALL THE FOLLOWING INFORMATION IF THIS FORM IS BEING USED TO DERIVE EMISSION FACTORS FOR A LIQUID STORAGE TANK WITH CAPACITIES GREATER THAN 250 GALLONS. FORM 2.5L MAY BE USED TO PROVIDE TANK INFORMATION FOR OTHER SOURCES OF EMISSION FACTORS. PLEASE INCLUDE ALL ORGANIC LIQUIDS, PETROLEUM PRODUCTS OR FUELS.

[1] TANK INFORMATION

POINT (TANK) IDENTIFICATION NO.	AIRS ID-PT	COLOR (ROOF)	COLOR (SHELL)
DIAMETER (FT)		PAINT CONDITION	SOLAR ABSORPTANCE
HEIGHT (FT)	LENGTH (FT)	TYPE OF ROOF ☐ CONE ☐ DOME ☐ OTHER (SPECIFY)	ROOF HEIGHT (FT)
CAPACITY (IN THOUSANDS OF GALLONS)			VAPOR SPACE OUTAGE (FT)
VENT PRESSURE SETTING	VENT VACUUM SETTING	TOTAL SOLAR INSULATION FACTOR (BTU/SQ FT)	

[2] CHEMICAL INFORMATION

CHEMICAL		WORKING LOSS PRODUCT FACTOR	
VAPOR MOLECULAR WT	CAS NUMBER	LBT (RANKINE)	D-MIN-AT (RANKINE)
LST - [AVERAGE LIQUID SURFACE TEMPERATURE (RANKINE)] AVG: MAX: MIN:		DVTR (RANKINE)	D-MAX-AT (RANKINE)
VP - [VAPOR PRESSURE AT LST (PSIA)]		DVR (PSI)	D-AVG-AT (RANKINE)
THROUGHPUT (IN THOUSANDS OF GALLONS)		NUMBER OF TURNOVERS	TURNOVER FACTOR

[3] VOC EMISSION CALCULATIONS

BREATHING LOSS (LBS/YR)

BREATHING LOSS = 26.714 X {DIAMETER}ˆ2 X {VAPOR SPACE OUTAGE} X {VAPOR MOLECULAR WEIGHT} X {VP}
X [({DVTR} / {LST}) + [({DVPR} - ({VENT PRESSURE SETTING} - {VENT VACUUM SETTING}))
/ (14.7 - {VP})]]) / [{LST} X [1 + (0.053 X {VP} X {VAPOR SPACE OUTAGE})]])

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WORKING LOSS (LBS/YR)

WORKING LOSS = 0.0238 X {VAPOR MOLECULAR WT} X {VP} X {THROUGHPUT} X {TURNOVER FACTOR}
X {WORKING LOSS PRODUCT FACTOR}

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BREATHING LOSS EMISSION FACTOR (LBS VOC PER 1,000 GALLONS CAPACITY) AND SCC

BREATHING LOSS EMISSION FACTOR = {BREATHING LOSS} / {CAPACITY}	BREATHING LOSS SCC
=	

WORKING LOSS EMISSION FACTOR (LBS VOC PER 1,000 GALLONS STORED) AND SCC

WORKING LOSS EMISSION FACTOR = {WORKING LOSS} / {THROUGHPUT}	WORKING LOSS SCC
=	

ENTER THE **CAPACITY** (BREATHING LOSS) AND **THROUGHPUT** (WORKING LOSS) AS THE **ANNUAL THROUGHPUT** IN BLOCK 4 ON SEPARATE FORMS 2.0 MAKING SURE THE SCC MATCHES THE BREATHING LOSS AND WORKING LOSS. ALSO ENTER THE CALCULATED **BREATHING LOSS EMISSION FACTOR** AND **WORKING LOSS EMISSION FACTOR** IN THE VOC BOX IN BLOCK 7 OF THE RESPECTIVE FORM 2.0.

DUPLICATE THIS FORM AS NEEDED.

INSTRUCTIONS

FORM 2.5 ORGANIC LIQUID STORAGE, FIXED ROOF TANK WORKSHEET

This form is **REQUIRED** if a facility **wants to calculate its own breathing and working loss emission factors** for fixed roof organic liquid storage tank(s) with a capacity greater than 250 gallons. If using Form 2.5 to calculate the VOC emissions from a storage tank, two separate Forms 2.0 should be completed, one for the breathing loss and one for the working loss from the tank.

The breathing and working loss emissions from more than one fixed tank may be grouped together under a single emission point for tanks that store the same organic chemical. If the fixed roof tanks to be grouped are not identical, a separate Form 2.5 may be needed to calculate the individual tank emissions before grouping the emissions into one emission point.

TANKS, the U.S. Environmental Protection Agency (EPA) computer software package, may also be used to calculate tank emission factors. If this method is used, attach a copy of the printout and list the tank information on a Form 2.5L. The TANKS software may be obtained by downloading the program from the EPA's Technology Transfer Network on the CHIEF Bulletin Board System at (919) 541-5285 or Internet address http://www.epa.gov/ttn/chief/tanks.html or by calling Region VII of the EPA at (913) 551-7020.

All of the information concerning the calculation of a VOC Emission Factor from fixed roof storage tanks was taken from the EPA Manual AP-42, Section 7.1. Reading this Section from AP-42 may provide a more in-depth explanation of the emission calculations for this type of equipment.

NOTE: Tables, Figures and other attachments are not included with these instructions. Please refer to EPA Manual AP-42, Section 7, or contact the Air Pollution Control Program at (573) 751-4817.

Complete the **Facility Name, FIPS County Number, Plant Number and Year of Data.**
See Form 1.0 instructions, page 1.0-1.

1) TANK INFORMATION

Point (Tank) Identification No.: This number is the unique identification number for each specific fixed-roof storage tank. This identification notation must match the point number entered on Form 1.1, Process Flow Diagram; Form 1.2, Summary of Emission Points; and Form 2.0, Emission Point Information.

AIRS ID-Pt: This is a three-character emission point identifier assigned by APCP staff. It is used as the Point Number in the EPA=s Aerometric Information Retrieval System=s Facility Subsystem database. Once this number is assigned to an emission point, it should remain constant from year to year, even if the Point ID supplied by the facility changes.

Diameter (Ft): Enter the diameter of the storage tank in feet. For horizontal tanks the effective diameter should be calculated using the formula below:

Effective Diameter = [{Tank Length} x {Actual Diameter} / 0.785] ^0.5

Height (ft): Enter the height of the tank for a circular tank in feet. For horizontal tanks leave this block blank.

Length (ft): Enter the length of the tank for horizontal tanks in feet. For circular tanks leave this block blank.
Capacity (in Thousands Gallons): The tank capacity should be expressed in thousands of gallons of liquid. A storage tank with a capacity of 10,000 gallons should be entered as 10 in this box.

Vent Pressure Setting (psig): This value is the breather vent pressure setting and should be expressed in pounds per square inch-gauge (psig). If specific information on the setting is not available, a default value of 0.03 psig may be used. If the fixed-roof tank is of bolted or riveted construction in which the roof or shell plates are not vapor tight, assume the vent pressure setting is equal to the vent vacuum setting even if a breather vent is used. The estimating equation for fixed-roof tanks does not apply if the vent pressure setting exceeds 1.0 (one) psig.

Vent Vacuum Setting (psig): This value is the breather vent vacuum setting and should be expressed in psig. If specific information on the setting is not available, a default value of -0.03 psig may be used. If the fixed-roof tank is of bolted or riveted construction in which the roof or shell plates are not vapor tight, assume the vent vacuum setting is equal to the vent pressure setting even if a breather vent is used. The estimating equation for fixed-roof tanks does not apply if the vent vacuum setting exceeds -1.0 psig.

Color (Roof): Enter the color and shade of the paint on the roof of the tank. Table 7.1-7 provides a list of the most common paint colors.

Color (Shell): Enter the paint color and shade of the shell or side of the tank. Table 7.1-7 provides a list of the most common paint colors.

Paint Condition: Enter the estimate of how well the paint covers the tank surfaces. The paint condition should be expressed as either "Good" or "Poor."

Color (Shell): Enter the paint color and shade of the shell or side of the tank. Table 7.1-7 provides a list of the most common paint colors.

Solar Absorbance: This factor is the amount of solar energy that the liquid stored in the tank absorbs. This factor is related to the color and condition of the paint on the roof and shell of the storage tank. This factor, a dimensionless number, may be obtained from Table 7.1-7.

Type of Roof: Check the box that matches the type of roof for the fixed tank. The equation used to calculate the Roof Height (Ft) (below) should correspond to the box checked for this field.

Roof Height (ft): Enter the distance, in feet, that the roof extends above the tank shell. Leave this field blank for a horizontal tank.

For Cone Roofs, this value can be determined from the following formula:
Cone Roof Height = 0.5 x Tank Cone Roof Slope x Shell Diameter

A default value of 0.0625 ft/ft can be used if specific information on the tank cone roof slope is unknown.
For Dome Roofs, this value may be determined by using the following formula:

Dome Roof Height = Tank Dome Roof Radius - (Tank Dome Roof Radius^2 - Tank Shell Radius^2)^0.5

> ***NOTE:*** The value of the Tank Dome Roof Radius usually ranges from 0.8 to 1.2 times the diameter of the tank. If this value is unknown, use the tank diameter in its place. In this case, the Roof Height is equal to 0.268 times the Shell Radius.

Vapor Space Outage (ft): This is the height, expressed in feet, of the average vapor space in the tank, including any volume corrections for the tank roof. One-half of the actual diameter of a horizontal tank should be used as the value for the vapor space outage. A value for the vapor space outage for vertical tanks may be calculated using the formula listed below:

Vapor Space Outage = {Tank Height} - {Liquid Height} + {Roof Outage}

The Roof Outage may be calculated using one of the following formulas:

For Cone Roofs:
Roof Outage = 0.33 x {Tank Roof Height}

NOTE: If the slope of the cone is unknown, use 0.0625 ft/ft as a default value.

For Dome Roofs:
Roof Outage = {Tank Roof Height} x [0.5 + [0.167 x ({Tank Roof Height} / {Tank Shell Radius})^2]]

If the tank diameter is used in place of the tank dome roof radius, the
Roof Outage = 0.0685 x {Shell Diameter}.

Total Solar Insolation Factor (BTU/Sq Ft): This factor is the daily amount of energy that the tank receives due to exposure to the sun. Unless site specific information is available, a value of 1402 BTU/ft^2 per day should be used as a default for this factor.

2) CHEMICAL INFORMATION

<u>Chemical</u>: Enter the name(s) of the chemical(s) stored in the tank during the calendar year.

<u>Vapor Molecular Weight</u>: The molecular weight of the vapor should be for the specific chemical stored in the tank during the year. The value entered should be expressed in pounds per pound-mole. If more than one chemical was stored in the tank at separate times during the year, a separate Form 2.5 should be completed for each material. The vapor molecular weight for selected petroleum and volatile organic liquids may be determined from Tables 7.1-2 and 7.1-3, respectively, or by analyzing vapor samples.

If the tank contains a mixture of different liquids, then the following equation should be used for calculating the vapor molecular weight of the mixture:

$$\text{Vapor Molecular Weight} = M_a(P_aX_a/Pt)+M_b(P_bX_b/Pt)+ \ldots +M_z(P_zX_z/Pt)$$

where the a, b, . . . , z represent different liquids and the M_a, M_b, . . . M_z terms the molecular weights of the respective compounds in the liquid. The X_a, X_b, . . . X_z terms represent the respective mole fraction of each component of the liquid and the P_a, P_b, . . . P_z terms the respective true vapor pressures of each different liquid. Pt is the total vapor pressure found by Raoult's Law, which is shown below:

$$Pt=P_aX_a+P_bX_b+ \ldots +P_zX_z$$

A more detailed discussion on this topic, is provided in AP-42, Section 7.1.

<u>CAS Number</u>: Enter the Chemical Abstract Service (CAS) Registry Number(s) for the chemical(s) stored in the tank during the calendar year.

<u>LST - [Average Liquid Surface Temperature (Rankine)]</u>:

Avg.: This value is the daily average surface temperature of the liquid stored in the tank, expressed in Rankine (R). If this value is unknown, it may be calculated using the formula below:

**LST = (0.44 x {D-Avg-AT (Rankine)}) + (0.56 x {LBT (Rankine)})
+ (0.0079 x {Solar Absorptance} x {Total Solar Insolation Factor})**

The D-Avg-AT (Daily Average Ambient Temperature) and the LBT (Liquid Bulk Temperature) are defined in the instructions below. The above equation should not be used to estimate the temperature for insulated tanks. For insulated tanks, the average liquid surface temperature should be based on the liquid surface temperature measurements from the tank.

Max: The Daily Maximum Liquid Surface Temperatures may be calculated using the

following formula:
Daily Maximum LST = {LST} + (0.25 x {DVTR})

Min: The Daily Minimum Liquid Surface Temperatures may be calculated using the following formula:
Daily Minimum LST = {LST} - (0.25 x {DVTR})

Temperatures in degrees Fahrenheit may be converted to degrees Rankine using the formula:

Rankine = Fahrenheit + 460

Temperatures in Degrees Celsius may be converted to degrees Rankine using the formula:
Rankine = (1.8 x Celsius) + 492

VP - [Vapor Pressure at LST (Psia)]: Enter the vapor pressure in pounds per square inch absolute (Psia) for the liquid being stored at bulk liquid surface temperature.

> ***NOTE:*** If the liquid stored in the tank is one of those listed in Table 7.1-2 or 7.1-3, use the true vapor pressure listed there. If the liquid stored is not listed on Table 7.1-2 or 7.1-3, the true vapor pressure can be estimated using Antoines Equation. For more information on how to calculate the true vapor pressures for organic liquids using Antoines Equation, consult AP-42, Section 7.1.

For Crude Oils

Use Figure 7.1-12a to calculate the true vapor pressure of the crude oil if the Reid vapor pressure is known. First find the stored liquid temperature (in Fahrenheit) on the scale at the right side of the page. The second step is to locate the Reid vapor pressure of the liquid on the scale that is in the middle of the figure. Next, draw a straight line from the stored liquid temperature, through the Reid vapor pressure point, to the true vapor pressure at the left side of the figure. Enter the true vapor pressure reading that is indicated on the scale that is on the left side of the page.

For Refined Petroleum Stocks

The true vapor pressure values for some refined petroleum products can be obtained from Table 7.1-2. Figure 7.1-13A may be used to find the true vapor pressure if the Reid vapor pressure is known. In this case, the first step is to find the stored liquid temperature on the scale at the right of the page. The second step is to locate the approximate position for the Reid vapor pressure, using the slope of the distillation curve on the small graph in the center of the page. The third step is to line up these two points and extend a straight line to the true vapor pressure scale at the left side of the page. Enter this value as the true vapor pressure of the liquid.

Throughput (in Thousands of Gallons): This value is the **annual** amount of the organic liquid that has been stored in the tank during the calendar year. This value must be expressed in **thousands of gallons** of liquid stored during the year. The value for the throughput should be the sum of the gallons of liquid stored in the tank at the beginning of the year plus the gallons replenished each time the tank was refilled minus any liquid left in the tank at the end of the year.

The following conversion factors should be used if the annual throughput is normally expressed in barrels. There are 42 gallons per barrel for U.S. petroleum products.

Working Loss Product Factor: This factor, a dimensionless number, is 0.75 for crude oils. For all other organic liquids, the product factor default is 1.0.

LBT (Rankine): The liquid bulk temperature should be calculated using the following formula:

LBT (Rankine) = {D-Avg-AT (Rankine)} + (6 x {Solar Absorptance}) - 1

DVTR (Rankine)]: This value for the Daily Vapor Temperature Range may be calculated using the formula:

**DVTR = [0.72 x ({D-Max-AT (Rankine)} - {D-Min-AT (Rankine)})]
+ (0.028 x {Solar Absorptance} x {Total Solar Insolation Factor})**

or using default values:

DVTR = 15.34 + (39.26 x {Solar Absorptance})

DVPR (psi)]: The value for the Daily Vapor Pressure Range may be calculated using the formula:

**DVPR = Vapor Pressure at Daily Maximum LST (psia)
- Vapor Pressure at Daily Minimum LST (psia)**

The vapor pressures at the daily maximum and minimum liquid surface temperatures may be found in the same manner as the Vapor Pressure at LST calculations discussed above. Use the respective temperatures in these calculations. A more detailed discussion on how to calculate vapor pressures at various temperatures is provided in AP-42, Section 7.1.

D-Min-AT (Rankine): This value is the Daily Minimum Ambient Temperature expressed in Rankine. The daily minimum ambient temperature information for selected cities may be found in Table 7.1.6 of the AP 42. If site-specific data is not available, a default value of 503.8 Rankine can be used for this value.

D-Max-AT (Rankine): This value is the Daily Maximum Ambient Temperature expressed in Rankine. The daily maximum ambient temperature Information for selected cities may be found in Table 7.1.6 of the AP 42. If site-specific data is not available, a default value of 525.1 Rankine may be used for this value.

D-Avg-AT (Rankine)]: This value is the daily average ambient temperature based on an annual average expressed in degrees Rankine. This value may be calculated using the formula:

D-Avg-AT = [{D-Max-AT (Rankine)} + {D-Min-AT (Rankine)}] / 2

Using the above defaults for the maximum and minimum ambient temperatures will result in a value of 514.45 Rankine for the daily average ambient temperature.

Number of Turnovers: This value is calculated by dividing the throughput by the tank capacity. Both values must be expressed in thousands of gallons.

Turnover Factor: This factor, a dimensionless number, may be obtained from Figure 7.1-17. If the number of turnovers is greater than 36, this factor may be calculated using the following formula:

Turnover Factor = (180 + {Number of Turnovers})
/ (6 x {Number of Turnovers})

For less than 36 turnovers per year, enter 1.0 (one) as the turnover factor.

3) VOC EMISSION CALCULATIONS

For fixed-roof storage tanks, VOC pollutants are usually emitted by two separate mechanisms. The first, called breathing loss is described as the release of vapors from the tank caused by vapor expansion and contraction. These VOC emissions usually result from changes in temperature and barometric pressure. The second mechanism by which VOC pollutants can be released from a fixed-roof storage tank is called working loss. Working losses are the combined vapor losses that occur as a result of repeatedly filling the storage tank and emptying it with organic liquid during the year.

In each box or on the reverse side of the worksheet, show all the steps in calculating the breathing loss and working loss emission factors.

<u>Breathing Loss Formula</u>: The first equation of Block 3 calculates VOC breathing losses from a fixed-roof storage tank. Breathing loss must be expressed in pounds of VOC emitted annually.

> ***NOTE:*** There is no breathing loss associated with underground storage tanks. Enter zero in this block and make sure the point description indicates that the tank is an underground storage tank.

<u>Working Loss Formula</u>: The second equation of Block 3 calculates VOC working losses from a fixed-roof storage tank. Working loss must be expressed in pounds of VOC emitted annually. The working loss equation presented on Form 2.5 is based on 42 gallons per barrel for petroleum liquids.

<u>Breathing Loss Emission Factor</u>: The breathing loss emission factor is computed by dividing the breathing loss by the capacity (expressed in thousands of gallons). This will give an emission factor expressed in pounds of VOC emitted per thousand gallons of tank capacity.

<u>Working Loss Emission Factor</u>: The working loss emission factor is computed by dividing the working loss by the annual throughput (expressed in thousands of gallons). This will give an emission factor expressed in pounds of VOC emitted per thousand gallons of an organic liquid processed annually.

Enter the SCC for both the **<u>Breathing Loss SCC</u>** and the **<u>Working Loss SCC</u>** next to the corresponding emission factor.

ENTER THE FOLLOWING ON FORM 2.0, EMISSION POINT INFORMATION:

<u>USE A SEPARATE FORM 2.O FOR EACH EMISSION FACTOR.</u>

Block 4 - Enter the **<u>Annual Throughput</u>** value (expressed in thousands of gallons).
Block 6 - Enter "25" in the VOC Box for Source of Emission Factor to indicate Form 2.5 was used to estimate the VOC emission factors for this tank.
Block 7 - Enter the **<u>Breathing Loss Emission Factor</u>** or the **<u>Working Loss Emission Factor</u>** in the VOC box.